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Short Communication

Genetic parameters of heterosis in F_1 and F_2 generations of chickpea (*Cicer arietinum* L.)

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The experimental material comprised 10 diverse lines of chickpea, *viz.*, five exotics ICC 987 from (*desi* USA), ICC 1073 (*desi* Spain), ICC 4914 (*kabuli* Grece), ICC 6148 (*kabuli* Jordan) and ICC 5033 (*desi* USSR) and five Indian varieties, K 850 (*desi* U.P.), JG 62 (*desi* M.P.), N 59 (*desi* Maharashtra), RS 11 (*desi* Rajasthan) and ICC 10035 (*kabuli* Mutant of L 550) crossed in half-diallel fashion. The resultant F_1s and F_2 populations along with parents were evaluated in a randomized block design with three replications at Indian Institute of Pulses Research, Kanpur. Observations were recorded on ten randomly selected plants in each parents and F_1s and on 20 plants in F_2s in each replication for nine characters (Table 1). The heterotic parameters were worked out as per the methodology of Gardner and Eberhart [1] and Singh [2].

Analysis of heterotic parameters (Table 1) revealed that general heterosis (hij), average heterosis (h-) and specific heterosis (sij) were found to be highly significant for all the characters except number of seeds/pod. Varieties (Vi) was also found highly significant for all the characters whereas, heterosis calculated by parameter (hij) showed that all the traits manifested heterotic effects. This confirmed the presence of adequate genetic diversity amongst parents and hybrids. Highly significant average heterosis (h^{-}) for all the attributes suggested the possibility of obtaining some elite segregants in the segregating generation which could be identified and exploited for the genetic improvement of the chickpea population.

Table 2 revealed the comparison of mean squares due to single degree of freedom for F_1s *vs* F_2s related to corresponding residual mean square for progenies. The mean square of average heterosis for single degree of freedom were larger than residual mean squares (F_1) for number of primary branches, number of secondary branches, 1000-seed weight, seed yield/plant and harvest index, indicating significant heterotic response whereas, it was low in the characters days to flower, plant height and seeds/pod. Mean squares for single degree of freedom for F_1s *vs* F_2s were higher than residual mean squares for F_1 in plant height, number of primary branches, number of secondary branches, pods/plant and harvest index and in F_2 for plant height, number of primary branches, number of secondary branches pods/plant and seed yield/plant only. Disproportionate magnitude was encountered in difference for F_1s *vs* F_2s as compared to average heterosis in all the characters suggesting considerable inbreeding depression in the F_2 populations [3]. Significant differences were recorded for average

Table 1. ANOVA for heterotic parameters for the nine characters in chickpea

Source	df	Days to flower	Plant height (cm)	No. of primary branches	No. of secondary branches	No. of pods per plant	No. of seeds per pod	1000-seed weight (g)	Seed yield per plant (g)	Harvest index (%)
Entries	54	11296151.86**	8117986.60**	234921.86**	873676.61**	51490439.03**	3828.26	118162593.65**	2888055.99**	5385067.18**
Varieties (vj)	9	928.69**	2678.04**	146.42**	553.91**	42050.44**	3.42**	42626.58**	1973.53**	629.78**
Heterosis (h_{ij})	45	11295223.18**	8115313.55**	234775.44**	873122.69**	1448388.58**	3824.84**	118219667.07**	2886082.46**	5384437.40**
General heterosis (h_j)	9	12.55**	172.36**	8.89**	33.33**	14945.13**	0.27	1224.67**	626.70**	33.01**
Average heterosis (h^{-})	1	8.10**	41.84**	38.03**	409.22**	36625.76**	0.00	3116763.87**	2102.22**	120.91**
Specific heterosis (S_{ij})	35	66.63**	101.99**	6484.62**	311.86**	37620.54**	0.63	7681.77**	3813.78**	145349.17**
Error	108	0.15	0.21	0.14	0.13	0.51	0.00	0.04	0.16	0.13

*,**Denote significance at 0.05 and 0.01 probability levels, respectively.

Table 2. Heterotic parameters in relation to heterosis and inbreeding depression in chickpea

Character	Parent mean	Cross mean		Mean squares			Average heterosis (h^-)	Average heterosis	Average heterosis in percent	Average inbreeding depression in percent
		F_1	F_2	F_1 *vs* F_2	Residual					
					F_1	F_2				
Days to flower	74.83	73.83	73.94	0.85	51.59	61.38	8.10**	–1.00	–1.34	–0.15
Plant height (cm)	64.78	62.52	64.21	191.88**	102.97	111.22	41.84	–2.26	–3.49	–2.70
No. of primary branches	8.57	10.74	9.00	204.28**	7.52	6.03	38.07**	2.17	25.32	16.20
No. of secondary branches	13.72	20.80	17.75	626.51**	42.77	31.80	409.22	7.08	51.60	14.66
No. of pods per plant	93.07	159.98	128.09	68649.45**	9292.67	6254.09	36625.76**	66.91	71.89	19.93
No. of seeds per pod	1.35	1.36	1.32	0.14	0.22	0.19	0.00	0.01	0.74	2.94
1000-seed weight (g)	23.22	239.33	237.20	304.26**	2289.61	2379.00	311676.87	216.11	930.71	0.89
Seed yield per plant (g)	21.86	37.89	35.37	429.45**	431.93	197.15	2102.22**	16.03	73.33	6.65
Harvest index (%)	47.32	51.17	50.22	59.70**	57.03	59.77	120.91**	3.85	8.14	1.86

*,** Denote significance at 0.05 and 0.01 probability levels, respectively.

heterosis in all the traits except seeds/pod as the least variation (1.00-1.70) among the parents and nonsignificant mean squares due to treatments were recorded in the present set of materials.

Considering both the average parental values and parental effects together, K 850 and JG 62 were superior parents for seed yield/plant, no. of secondary branches/plant and plant height. The *gca* and parent effects are identical only when gene frequencies are half and epistasis is absent [4]. This indicated that epistasis present in sizeable magnitude is influenced by linkage. Comparison of data in respect of heterotic response and specific heterotic effects showed a considerable similarity in the pattern of results acheived. The parents involved in these crosses were ICC 10035 and ICC 4914 being the *kabuli* type and K 850, JG 62, ICC 987 and N 59 as *desi* types with different eco-geographic origin and gene pools. Cross ICC l0035 (*kabuli*) × K 850 (*desi*) exhibiting maximum standard heterosis involved both parents "with good general combining ability" and can be exploited straightway through simple selection scheme.

In view of very high estimates of standard hetetosis for seed yield and its important component traits, heterosis breeding "will be one of the procedure to encash the predominant non-additive genetic variance for these traits". However, in absence of functional male sterility in chickpea, heterosis breeding approach may not be a practical proposition. Jensen's [5] diallel selective mating system and its modification [6] would result into population having desirable recombinants and can be exploited for obtaining a superior high yielding chickpea variety.

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